BLUE DIAMOND
Industries, LLC

Quality System Manual for the Eastern States Consortium HDPEP (High Density Polyethylene Pipe) Program

Participating States: CT, DE, DC, ME, MD, MA, NC, NH, NJ, NY, PA, RI, VT, VA

Corrugated Polyethylene Pipe

3399 Tates Creek Road, Suite 110
Lexington, KY 40502

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August 30, 2006

Mission Statement

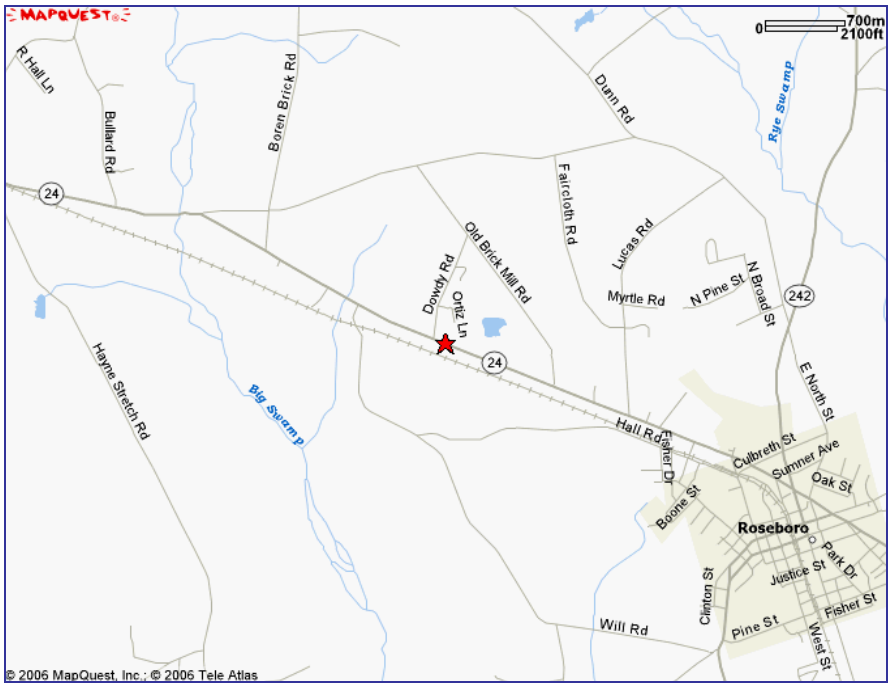
The quality mission of Blue Diamond Industries (BDI) is to establish a culture within the business of producing corrugated polyethylene piping within the required specifications. This will be accomplished by controlling both raw materials and the manufacturing process, by testing, and by conducting visual inspections. Accountability will be documented and will be traceable through recording dates, shifts, and production runs. The goal is to continually improve quality and prevent shipment of any product not meeting required specifications.

Location

Blue Diamond Industries' corporate headquarters are located in Lexington, KY. BDI also has three manufacturing plants located in Middlesboro, KY, Roseboro, NC, and Oneonta, AL. The North Carolina and Alabama plants manufacture corrugated polyethylene pipe. The Kentucky facility manufactures solid wall polyethylene conduit.

North Carolina

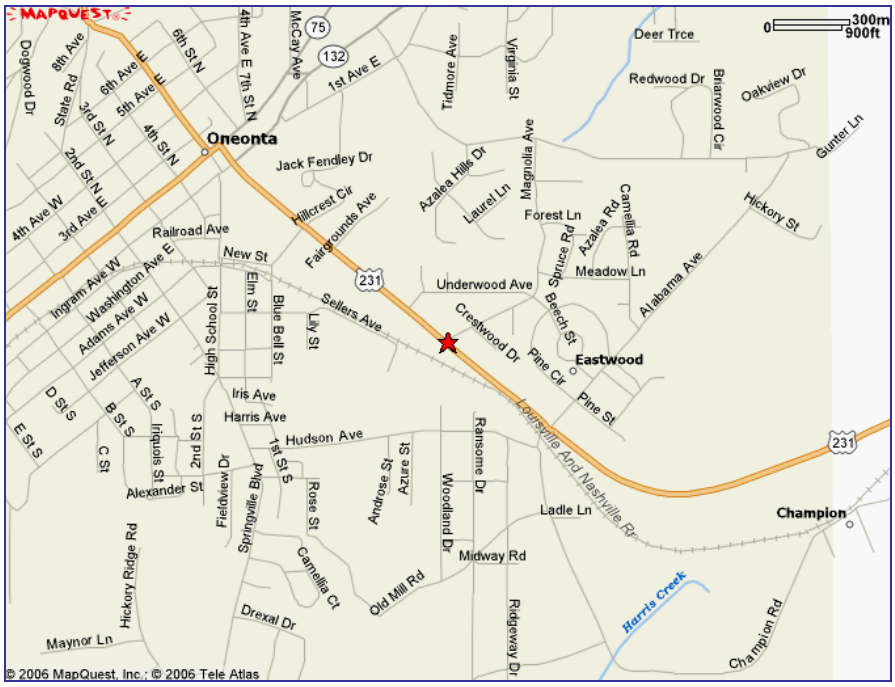
The Roseboro facility is located on HWY 24. Approaching from Fayetteville on HWY 24, BDI is located on the right, approximately twenty miles east of Interstate 95. Approaching from Clinton, BDI is located on the left, approximately four miles west of the Route 242 intersection. The facility is clearly marked with a BDI sign.



BDI, Roseboro manufactures 3" through 8" Types C, CP, S, and SP in accordance with AASHTO M-252. This location also manufactures 12" through 24" Types C, CP, S, and SP in accordance with AASHTO M-294.

Alabama

The Oneonta facility is located at 415 6th Street in Oneonta.



The BDI, Oneonta facility manufactures 4" through 10" Types C, and CP in accordance with AASHTO M-252.

BDI is currently not seeking ESC approval for the Alabama manufacturing facility.

Sampling and Testing Procedures

Approved Technician: North Carolina Facility

All sampling, testing, and recording shall be done by the approved BDI technician(s) located at the North Carolina facility. These persons will have been trained and tested in accordance with all applicable DOT and agency standards. BDI technicians can be reached at 910.525.5121.

Key Personnel:

- George Zagorski, P.E. – Vice President / Program Manager 859.224.0415 (Corporate Headquarters, Lexington, KY)
- Kenny Stafford – Testing and Quality Control (NC)
- Curtis Maroschak – Plant Manager (NC)

- Kenny Poole – Materials Control (NC)
- Ken Flammang – Vice President Manufacturing 770.297.9871 (Atlanta, GA Office)

Independent Laboratory Testing

In the case that BDI does not have the required testing equipment, an independent laboratory will be employed to perform interim testing. BDI will use on of the following laboratories:

- TRI Environmental Inc.
  9063 Bee Caves Road
  Austin, TX 78733
  Contact: Joel Sprague
    - TRI is a NTPEP certified laboratory.
- Ohio University, Civil Engineering Department
  Athens, OH 45701
  Contact: Dr. Terry Masada
    - Ohio University is a NTPEP certified laboratory.
- HC Nutting Co., Corporate Center
  611 Lunken Park Drive
  Cincinnati, OH 45226
  Contacts: Dr. Steven Zhou; Tim Goodhall
    - HC Nutting, with over 80 years of experience, is nationally recognized for its materials and geotechnical testing laboratory. HC Nutting employs 60 professional engineers, scientists, and geologists.

Pre-Production

BDI performs material evaluations on all incoming material. The incoming material evaluations consist of a minimum density (ASTM D1505) and melt index (ASTM D1238) on each lot of material, to confirm that the resin meets the required cell classification. Samples should be taken randomly from each lot of resin delivered. Adequate material should be sampled for two sets of complete tests (in case a re-test is necessary.) Additionally:

- For M-252 products:
    - Single stream resins must have a certificate of analysis indicating the virgin resin meets the melt index and density requirements of M-252.
    - Resin blends must have a certificate of analysis indicating the blend of each lot conforms to M-252.
        - Additionally, the component resins must have a certificate of analysis indicating lot specific density and melt index.
        - The resin blend shall be tested for density and melt index to confirm that it meets M-252.
- For M-294 products:
    - Single stream resins shall be certified to meet Section 6.1 of AASHTO M-294, either through PPI listing or testing by a third party.

- The NCLS test must be performed on the first lot of resin, and then quarterly with continued use.

- Resin blends shall be certified to meet Section 6.1 of AASHTO M-294 by a third party testing lab. Follow-up testing for melt index and density must be done for each lot to verify the certification.
  - The NCLS test must be performed on the first lot of resin, and then quarterly with continued use.
  - The component resins and percentages must be provided to ESC auditors or their agents as requested.

If resin is clear, test for carbon black once daily. If resin comes fully formulated, test per lot of resin, or use the test results from the resin producer.

A lot is identified as a shipment (no larger than a railcar compartment or truckload) of polyethylene resin. If a truckload or railcar has more than one lot of polyethylene resin and corresponding supplier certifications, then a material evaluation will be required for each lot.

During Production

Lot Sizes

Lot sizes are defined as no larger than a production run per diameter per machine. Samples should be randomly collected at varying times during production or shift changes, depending on the frequency of the required tests.

Carbon Black

The carbon black content of the resin must be verified each day.

Unit Weight

Unit weight tests are performed for all products manufactured. Testing is performed during every material lot change and shift change. This test will be per diameter, per machine, minimum two per shift or material change.

Wall Thickness

Wall thickness measurements for uniformity shall be performed at least two times per shift or with every material lot change. This test shall be performed with an approved measuring device such as calipers or micrometers in accordance with ASTM 2122.

Inside Diameter

Inside diameter measurements will be taken and noted once per work shift.

Pipe Length

Pipe length measurements will be taken and noted once per work shift.

Perforations

Perforations and slot dimensions shall be measured once per work shift. Water inlet area will also be calculated once per work shift.

Visual Inspection

Continuous visual inspections shall be performed on the interior and exterior wall for bonding, cracks, material distribution, perforation dimensions, locations and water inlet areas, blowouts, markings, etc., during production and noted once per work shift.

Pipe shall be permanently marked in accordance with AASHTO M-252 or M-294, whichever is appropriate.

Post Production

A final visual inspection shall be performed on all finished pipe.

All sampling, record-keeping, and testing will be completed by the approved technician and forwarded to the appropriate location(s).

Brittleness Test

Testing will be performed by an approved outside laboratory in accordance with ASTM D2444 and AASHTO standards twice per week or per lot, whichever is more frequent.

Pipe Flattening

Testing will be performed by an approved outside laboratory in accordance with ASTM D2412 and AASHTO standards two times per week or per lot, whichever is more frequent.

Pipe Stiffness

Testing will be performed by an approved outside laboratory in accordance with ASTM D2412 and AASHTO standards two times per week or per lot, whichever is more frequent.

Elongation

Testing will be performed by an approved laboratory in accordance with ASTM F405 and AASHTO M-252 standards, once per year.

Low Temperature Flexibility

Testing will be performed by an approved outside laboratory in accordance with AASHTO M-252 standards once per year.

ESC

Testing will be performed by an approved outside laboratory in accordance with AASHTO M-252 or M-294, as applicable, once per year.

Joint Integrity

Testing will be performed quarterly for integral bell and spigot.

Couplings & Fittings

Couplings will be tested for joint integrity, joint strength, and joint alignment by the BDI approved technician in accordance with AASHTO M-252 and M-294.

Fittings manufactured by BDI shall be identified by the process and the resin lot shall be identified via the resin testing and certification outlined previously. Fittings shall be manufactured with material meeting AASHTO M-252 or M-294 as appropriate.

Fittings purchased (out-buys) shall have certification from the manufacturer they were produced with the material requirements of AASHTO M-252 or M-294 as appropriate. Documentation shall be provided to show the manufacturer, process, and material specifications.

Type and Description of Equipment Available at BDI Laboratory

Current versions of all applicable ASTM and AASHTO standards shall be maintained.

- ZWICK Flow Test Apparatus, Type 4106 Melt Index
- OHAUS E-series Electronic Balances, Model E 400-D
- Electroscale Model 438, SNFESK 60817
- Density Indicators
- Brittleness Impact Tester (Forthcoming)
- Stiffness/Flattening Machine (Forthcoming)

Maintenance on any equipment must be recorded and documented. Equipment shall be calibrated per the manufacturer's recommendations, at least annually.

Quality Control Test Forms for Independent Laboratory and/or BDI Laboratory

Forms shall contain:

- Name and Address of Testing Laboratory
- Identification of the Report and Date Issued
- Identification of the Lot Represented by the Sample
- Description, Identification, and Condition of the Test Sample
- Date and Receipt of the Test Sample
- Identification of the Standard Test Method Used
- Test Results and All Other Pertinent Data Required by the Standard Test Method
- Identification of Any Test Results Obtained by the Subcontractor
- Name of the Person(s) Accepting Technical Responsibility for the Test Report

Sample Identification and Record Keeping – BDI Laboratory

Raw Materials

All raw material samples to be tested are collected and stored in closed containers. The samples are identified by a form that is placed in the container describing the material, delivery date, test date, lot number, and results from the melt index and density tests. A test number is given to the sample so that the material can be traced to the finished product. The numbers will be consecutive and easily cross-referenced to the finished product. After all tests are completed, the results are recorded on the form and filed per DOT specifications.

Pipe Samples for Testing

Each sample for quality control shall be assigned a control number for record keeping and traceability. The test report shall identify the plant, date and shift of the manufacturer, production line, and lot number for the polyethylene resin. Test reports shall be maintained for a minimum of five years. ESC inspection reports shall also be maintained for a period of five years. These reports shall be available to ESC agents, qualified DOT inspectors, or their agents.

Resolutions of Non-conforming Products

Reports shall clearly identify non-conforming test results. Product produced subsequent to non-conforming test results shall be clearly identified and quarantined pending investigation of the failure.

A second sample from the quarantined lot shall be taken and tested. If the second sample meets the test requirements, the lot shall be released for shipment, and the reason for the original failure shall be documented. If the second sample fails, corrective action shall be taken to bring the product into conformance and the action noted in the test report. A second sample shall be taken to verify that the deficiency has been corrected. If this sample also fails, then the process will be repeated until the deficiency has been resolved.

All non-conforming material shall be segregated in the inventory.

QA/QC Comparison Results

Test results from separate laboratories will not provide exactly identical values. Acceptable deviations in results are as follows:

- Density: 3% ASTM D1505
- Melt Index: 15% ASTM D1238
- Pipe Stiffness: 10% ASTM D2412
- Other Tests: 5%

Quality Control Technician Lines of Authority

The quality control technician shall perform all the testing aforementioned and keep records as indicated in this QSM. He shall report to the production manager the results of the testing. In the event of non-conformance, the quality control technician will inform the plant manager, and the production will be adjusted, and changes will be noted, so that the product will be in conformance. In the event the plant manager does not, or chooses not to implement the corrective action(s), the quality control technician will report to the Quality Control Director, a vice president of the company, who (along with the vice president of manufacturing,) has the authority to mandate the corrective action.

Quality Control Technician Training and Testing

The Quality Control Director shall train, test, and observe the quality control technician performing the tests and procedures aforementioned. Additionally, the Director will test the technician in the applicable ASTM and AASHTO standards. Initial training and subsequent re-training, or updates for new and revised standards, shall be recorded. Documentation shall be maintained and available to ESC inspectors, DOT inspectors, or their approved agents.

Quality Control Audits

The Quality Control Director shall on at least an annual basis, perform a quality audit that includes an inspection of the plant and laboratory. He will observe the resin and product sampling techniques, test procedures, reporting procedures, and will review the documentation. He will also review documentation concerning non-conforming products and the corrective actions taken.

The Director shall discuss the audit with plant managers and issue a report to be kept at the manufacturing facility. The report will be available to ESC inspectors.

National Transportation Product Evaluation Program

On an annual basis, BDI will submit two sizes of pipe to an approved independent laboratory for testing in accordance with AASHTO M-294. An ESC representative will select and label the samples to be tested. One sample shall be tested by BDI and the results will be compared to the results from the independent laboratory. Results shall be reported to ESC along with an explanation of any corrective action taken due to comparative results with significant differences between BDI and independent labs.

Annual Registration and Guarantee

As required by the specifying DOT or agency, BDI will submit a notarized Annual Registration and Guarantee to the state material engineer.

QSM Posting

A copy of the QSM will be posted in the quality control laboratory, the NC office, the production office near the safety information, as well as in the Technical Library located in the corporate office in Lexington, KY. Each head of production will be given an individual copy of the QSM. All employees are given free access to the QSM documents.

Mark Stuhlreyer

Mark Stuhlreyer, President
Blue Diamond Industries, LLC
August 30, 2006

George A. Zagorski, PE
Résumé

Education

- MS Business Administration, Indiana University at South Bend, 1981
- BS Civil Engineering, Illinois Institute of Technology, 1976
- "Hypercompetition" (Executive Course), Tuck School of Business, Dartmouth College, 1997

Affiliations

- Licensed Professional Engineer in Illinois and Indiana
- Member ASTM

Work Experience

- Blue Diamond Industries (BDI), LLC, Lexington, KY, 2004 – Present
  - Vice President of Sales and Technical Director
  - BDI is a manufacturer of polyethylene conduit for the telecommunication and electrical construction industries. Additionally, BDI manufactures corrugated polyethylene pipe for the civil and heavy highway industries.
- Moore DP, LLC, Lexington, KY, 2000 - 2004
  - Vice President of Sales
  - Moore was a manufacturer of outside plant construction products and contractors to the CATV, telecom, and electrical industries.
- National Seal Company (NSC), Aurora, IL, 1985 – 2000
  - President / CEO 1999 – 2000
  - Executive Vice President / COO 1997 – 1999
  - Senior Vice President 1995 – 1997
  - Vice President Sales and Marketing 1990 – 1995
  - Vice President *Fluid Systems (FSI)*, a subsidiary of NSC, 1985 – 1990
  - A leading manufacturer of synthetic plastic products, and multi-national construction company, in the environmental, civil engineering, building, and heavy/highway industries. NSC was a subsidiary of Waste Management Inc. (WMI), a $15 billion environmental services company.
- CONTECH (formerly ARMCO STEEL, CONST. PROD. DIV.) 1976 – 1985
  - Manager Allied Products, Middletown, OH, 1984 – 1985
  - District Engineer, Chicago, IL, 1983 – 1984
  - District Sales Engineer, Chicago, IL, 1981 – 1983
  - Sales Engineer, South Bend, IN, 1976 – 1981
  - Sales Trainee, Middletown, OH 1976
  - A $200 million division of Armco Steel, manufacturing steel and plastic products used in infrastructure construction and rehabilitation.

BLUE DIAMOND INDUSTRIES
QC Test Form

WALL THICKNESS

(Page 1 of 2)

TECHNICIAN NAME _____ RESIN LOT # _____

PIPE SIZE _____ DATE _____ PIPE LOT # _____

Outer Wall Thickness	1st Shift SAMPLE			2nd Shift SAMPLE			3rd Shift SAMPLE		
	1	2	3	1	2	3	1	2	3
Top									
Top Right									
Right									
Bottom Right									
Bottom									
Bottom Left									
Left									
Top Left									

High Reading									
Low Reading									
Average									

WALL THICKNESS

(Page 2 of 2)

Inner Wall Thickness	1st Shift SAMPLE			2nd Shift SAMPLE			3rd Shift SAMPLE		
	1	2	3	1	2	3	1	2	3
Top									
Top Right									
Right									
Bottom Right									
Bottom									
Bottom Left									
Left									
Top Left									

High Reading									
Low Reading									
Average									

(PASS / FAIL)

BLUE DIAMOND INDUSTRIES
QC Test Form

PIPE WEIGHT, PIPE LENGTH, VISUAL, INSIDE DIAMETER

(Page 1 of 2)

TECHNICIAN NAME _____ RESIN LOT # _____

PIPE SIZE _____ DATE _____ PIPE LOT # _____

PIPE WEIGHT

	1st Shift SAMPLE			2nd Shift SAMPLE			3rd Shift SAMPLE		
Pipe Weight	1	2	3	1	2	3	1	2	3

Measurement									

(PASS / FAIL)

PIPE LENGTH

	1st Shift SAMPLE			2nd Shift SAMPLE			3rd Shift SAMPLE		
Pipe Length	1	2	3	1	2	3	1	2	3

Measurement									

(PASS / FAIL)

PIPE WEIGHT, PIPE LENGTH, VISUAL, INSIDE DIAMETER

VISUAL

Visual	1st Shift SAMPLE			2nd Shift SAMPLE			3rd Shift SAMPLE		
	1	2	3	1	2	3	1	2	3

Pass / Fail									

(PASS / FAIL)

INSIDE DIAMETER

Inside Diameter	1st Shift SAMPLE			2nd Shift SAMPLE			3rd Shift SAMPLE		
	1	2	3	1	2	3	1	2	3

Measurement 1									
90° from First									
Average									

(PASS / FAIL)

BLUE DIAMOND INDUSTRIES
QC Test Form

PERFORATIONS AND WATER INLET AREA

TECHNICIAN NAME RESIN LOT #

DIAMETER DATE PIPE LOT #

SLOTS

Slots	1st Shift SAMPLE			2nd Shift SAMPLE			3rd Shift SAMPLE		
	1	2	3	1	2	3	1	2	3
Width									
Length									
Spacing									
Number of slots									
Area (W x L)									
Water Inlet Area (A/Spacing)									

(PASS / FAIL)

PERFORATIONS

Perforations	1st Shift SAMPLE			2nd Shift SAMPLE			3rd Shift SAMPLE		
	1	2	3	1	2	3	1	2	3
Diameter									
Spacing									
# of Perforations									
Area									
Water Inlet Area (A/Spacing)									

(PASS / FAIL)

BLUE DIAMOND INDUSTRIES
QC Test Form

BRITTLENESS

(Twice per week or per lot)

TECHNICIAN NAME _____ RESIN LOT # _____

DIAMETER _____ DATE _____ PIPE LOT # _____

BRITTLENESS

Date	Sample	Pass	Fail
	1		
	2		
	3		
	1		
	2		
	3		

(PASS / FAIL)

BLUE DIAMOND INDUSTRIES
QC Test Form

ELONGATION

(Once per year)

TECHNICIAN NAME RESIN LOT #

DIAMETER DATE PIPE LOT #

LOAD

ELONGATION

Elongation Increase (mm)	Sample	1	
		2	
		3	
		Average Elongation (measurement x 100%/760 mm)	

(PASS / FAIL)

BLUE DIAMOND INDUSTRIES
QC Test Form

ESC (ENVIRONMENTAL STRESS CRACK)

(Once per year)

TECHNICIAN NAME _____ RESIN LOT # _____

DIAMETER _____ DATE _____ PIPE LOT # _____

ESC

Date	Sample	Pass	Fail
	1		
	2		
	3		

(PASS / FAIL)

BLUE DIAMOND INDUSTRIES
QC Test Form

LOW TEMPERATURE FLEXIBILITY

(Once per year)

TECHNICIAN NAME _____ RESIN LOT # _____

DIAMETER _____ DATE _____ PIPE LOT # _____

LOW TEMPERATURE FLEXIBILITY

Date	Sample	Pass	Fail
	1		
	2		
	3		

(PASS / FAIL)

BLUE DIAMOND INDUSTRIES
QC Loading Form

DATE:
PIPE SIZE:
LOT #:
DATE MADE:
SHIPPED TO:
VISUAL INSPEC.:
LOADING SUPERVISOR SIGNATURE:

BLUE DIAMOND INDUSTRIES
Material Data Sheet

DATE MATERIAL RECEIVED:
SUPPLIER:
LOT #:

QC Test Results

SAMPLE DATE:
TECHNICIAN:
MELT INDEX:
DENSITY:
NOTES:

SIGNATURE:	DATE:

Sample Report

Independent Lab

STIFFNESS

FLATTENING

Date: June 12, 2006

To: Kenneth Poole
Purchasing Manager - Blue Diamond Industries, LLC
P.O. Box 905, Roseboro, North Carolina 28382
Telephone: (910) 525-5121
E-Mail: kpoole@bdiky.com

and

George Zagorski, PE
Vice President – Blue Diamond Industries, LLC
3399 Tates Creek Road, Suite 110
Lexington, Kentucky 40502
Telephone: (859) 224-0415
E-Mail: geogez@bdiky.com

From: Dr. Terry Masada
Civil Engineering Dept.
Ohio University, Athens, OH 45701
Tel: (740) 593-2474
Fax: (740) 593-0625
E-Mail: masada@bobcat.ent.ohiou.edu

Re: Parallel-Plate Load Testing of 24-inch Dia. HDPE Pipe Specimens

I have completed the parallel-plate load testing of the 24-inch diameter corrugated HDPE pipe specimens. All the tests were performed in full accordance with the ASTM D-2412 test protocol. Prior to the testing, each test specimen was conditioned for two days at room temperature of 22 °C in the laboratory.

The test results are presented in detail on the following pages. The test specimens were loaded in three different positions with respect to the seam location. The seam of Test Pipe #1 was located at 4:30 and 10:30 clock positions. The seam of Test Pipe #2 was located at 6:00 and 12:00 clock positions. The seam of Test Pipe #3 was located at 3:00 and 9:00 clock positions. As summarized on page 11, the average pipe stiffness (PS) value at 5% vertical deflection was 34.1 lb/in/in (= 235.1 kPa). The minimum PS value required for 24-inch (600-mm) diameter HDPE pipe is 34.08 lb/in/in (= 235 kPa) according to AASHTO M-294. Also, note that two of the three test specimens developed wall buckling while being loaded to 30% vertical deflection. Please contact me if you have any questions or comments regarding the test results.

The cost of performing all the tests and report preparation will be $300. Please issue a check payable to Ohio University – Civil Engineering Dept. I enjoyed working with you on this small project.

Parallel-Plate Load (ASTM D-2412) Test – Data Sheet

Description of Test Pipe	24" Dia. Corrugated HDPE (Test Specimen 1)		
Manufacturer	Blue Diamond Industries		
Time/Date of Testing	11:30 a.m. on June 7, 2006		
Room Temperature	22 °C		
Test Performed by	Dr. T. Masada		
Length of Test Specimen (inches)	(L1) 23.387	(L2) 23.278	(L3) 23.410
	(L4) 23.321	Ave. L = 23.349	
Wall Thickness of Test Specimen (inches)	(T1) 2.109	(T2) 2.081	(T3) 2.100
	(T4) 2.069	(T5) 2.071	(T6) 2.071
	(T7) 2.111	(T8) 2.134	Ave. T = 2.093
Outside Diameter of Test Specimen (based on caliper measurements)	Max. OD = NA	Min. OD = NA	
	Ave. OD = NA		
	[Note] This product is ID-controlled. OD = ID + 2T = 23.349 + 2(2.093) = 28.072 inches.		
Inside Diameter of Test Pipe (based on caliper measurements) (inches)	(ID1) 23.897	(ID2) 23.878	(ID3) 23.850
	(ID4) 23.917	Ave. ID = 23.886	
Test Results (see also Figure 10 on Page 11)	Pipe stiffness (PS) values are: 34.85 lb/in/in @ 05% deflection 28.20 lb/in/in @ 10% deflection 23.28 lb/in/in @ 15% deflection 18.63 lb/in/in @ 20% deflection 12.21 lb/in/in @ 30% deflection [Note] Loading rate set at 0.5 in/minute.		
Additional Information (see Figures 1 through 3 in this report)	File No. = #53-6 The pipe is positioned so that the seam is located at 1:30 and 7:30 clock positions. At 20% vertical deflection the wall section at the crown started being crimped. A slight reversed curvature also began appearing at the top. The load vs. deflection curve exhibited a peak at 20% deflection.		

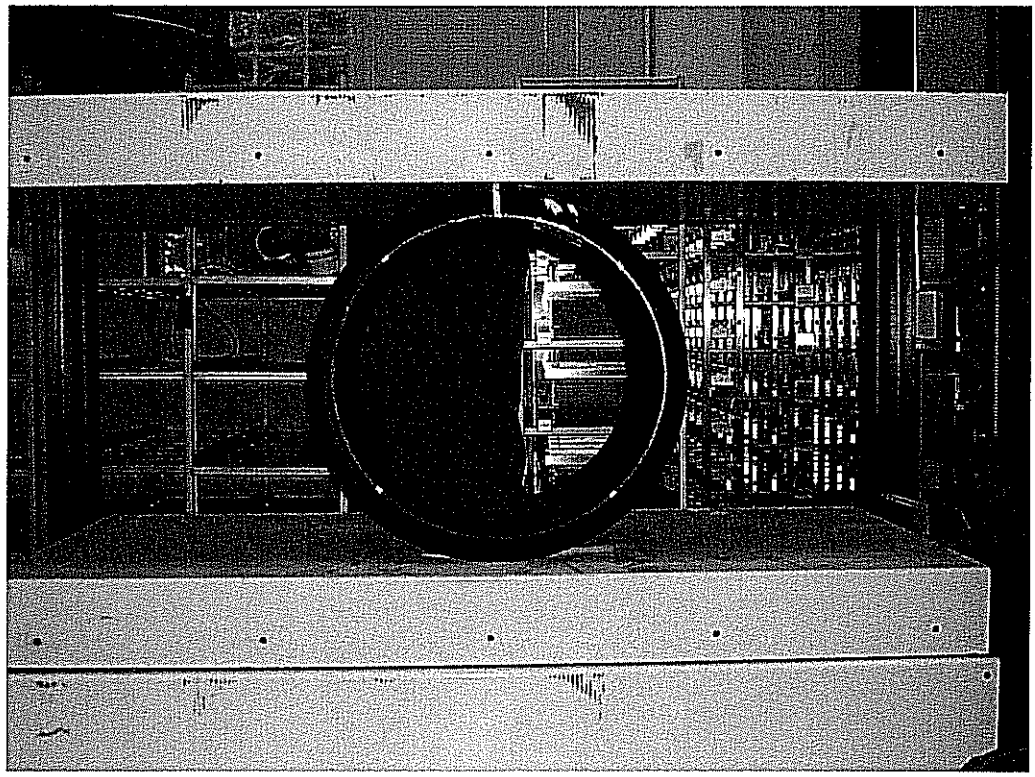


Figure 1: Test Pipe #1 at Beginning of Parallel Load Test

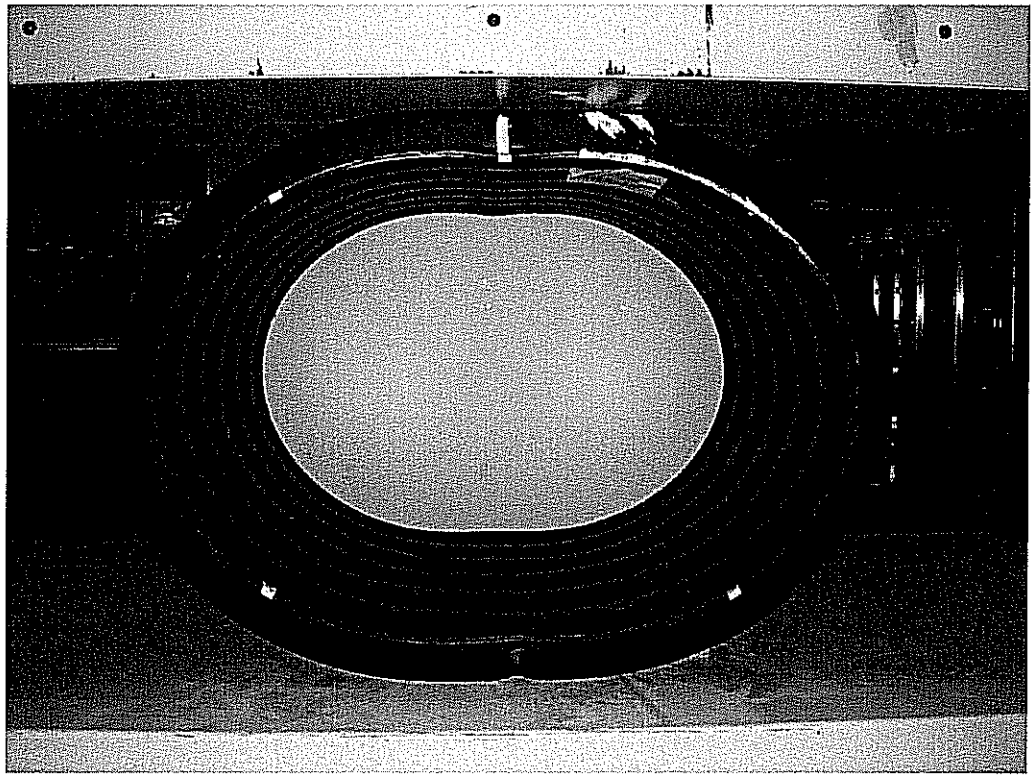


Figure 2: Test Pipe #1 Loaded to 30% Vertical Deflection

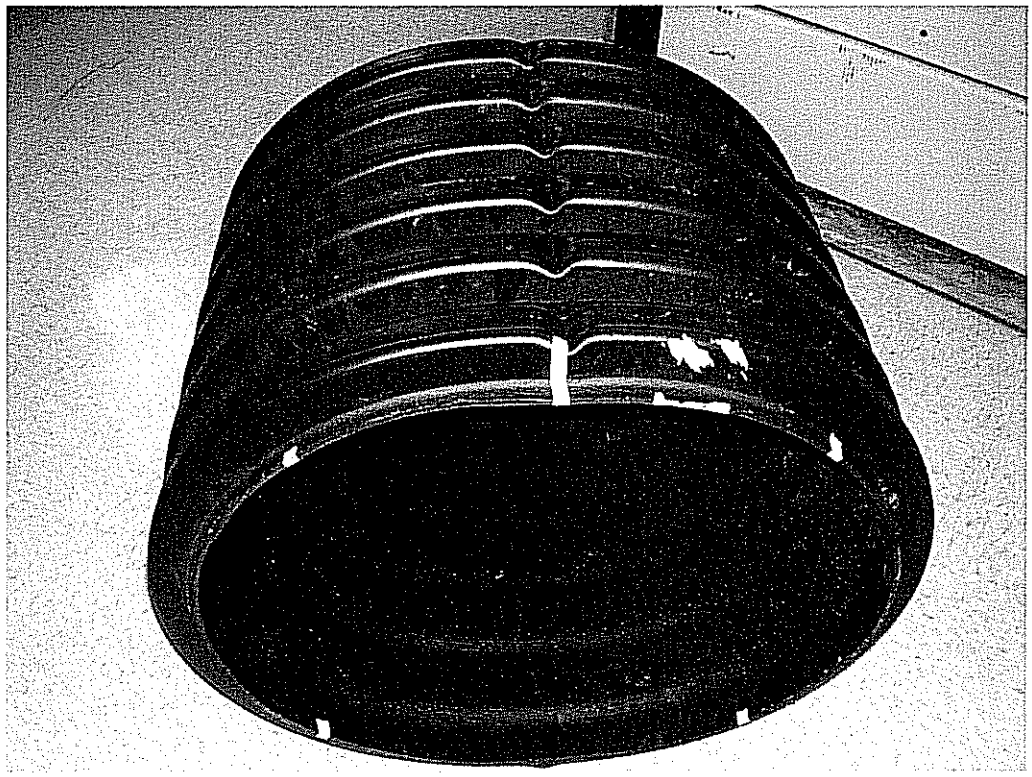


Figure 3: Test Pipe #1 Immediately After Load Test

Parallel-Plate Load (ASTM D-2412) Test – Data Sheet

Description of Test Pipe	24" Dia. Corrugated HDPE (Test Specimen 2)		
Manufacturer	Blue Diamond Industries		
Time/Date of Testing	2:35 p.m. on June 7, 2006		
Room Temperature	22 °C		
Test Performed by	Dr. T. Masada		
Length of Test Specimen (inches)	(L1) 23.369	(L2) 23.505	(L3) 23.628
	(L4) 23.540	Ave. L = 23.511	
Wall Thickness of Test Specimen (inches)	(T1) 2.070	(T2) 2.045	(T3) 2.120
	(T4) 2.171	(T5) 2.153	(T6) 2.076
	(T7) 2.074	(T8) 2.073	Ave. T = 2.098
Outside Diameter of Test Specimen (based on caliper measurements)	Max. OD = NA	Min. OD = NA	
	Ave. OD = NA		
	[Note] This product is ID-controlled. OD = ID + 2T = 23.935 + 2(2.098) = 28.131 inches.		
Inside Diameter of Test Pipe (based on caliper measurements) (inches)	(ID1) 23.960	(ID2) 23.980	(ID3) 23.920
	(ID4) 23.880	Ave. ID = 23.935	
Test Results (see also Figure 11 on Page 12)	Pipe stiffness (PS) values are: 33.99 lb/in/in @ 5% deflection 28.11 lb/in/in @ 10% deflection 23.43 lb/in/in @ 15% deflection 19.53 lb/in/in @ 20% deflection 11.92 lb/in/in @ 30% deflection [Note] Loading rate set at 0.5 in/minute.		
Additional Information (see Figures 4 through 6 in this report)	File No. = #53-7 The pipe is positioned such that its seam is located at 12:00 and 6:00 clock positions. At about 22% vertical deflection the wall section at the crown started being crimped. A slight reversal of curvature also began appearing at the top at that stage as well. The load vs. deflection curve exhibited a peak at 22% deflection.		

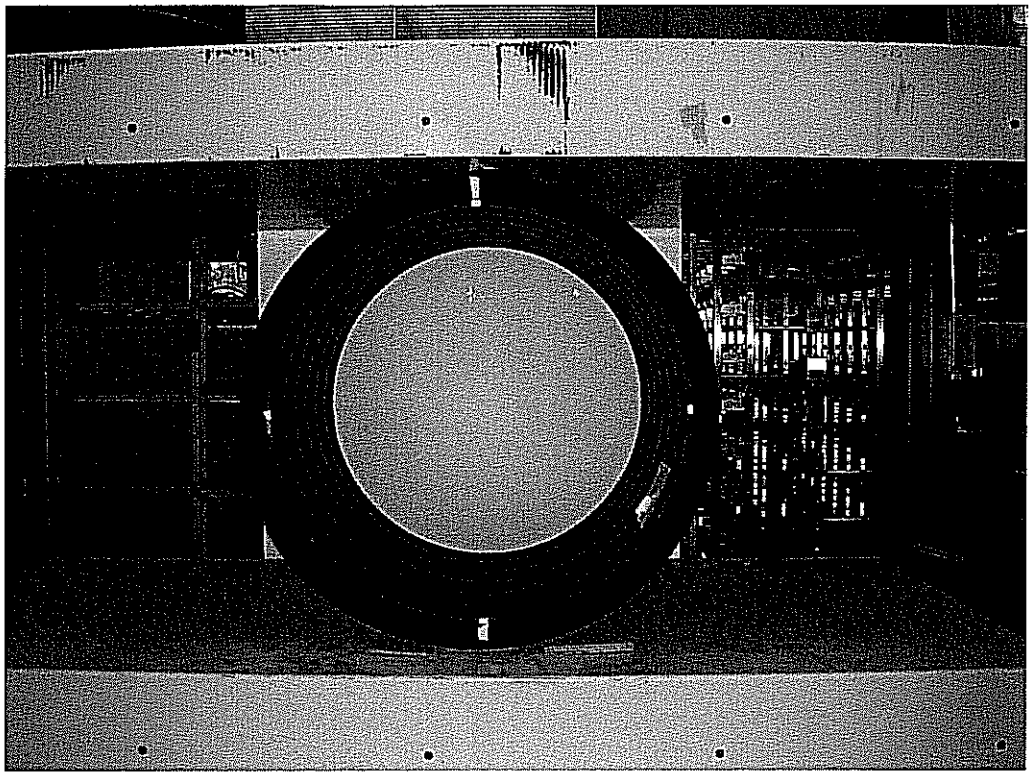


Figure 4: Test Pipe #2 at Beginning of Parallel Load Test

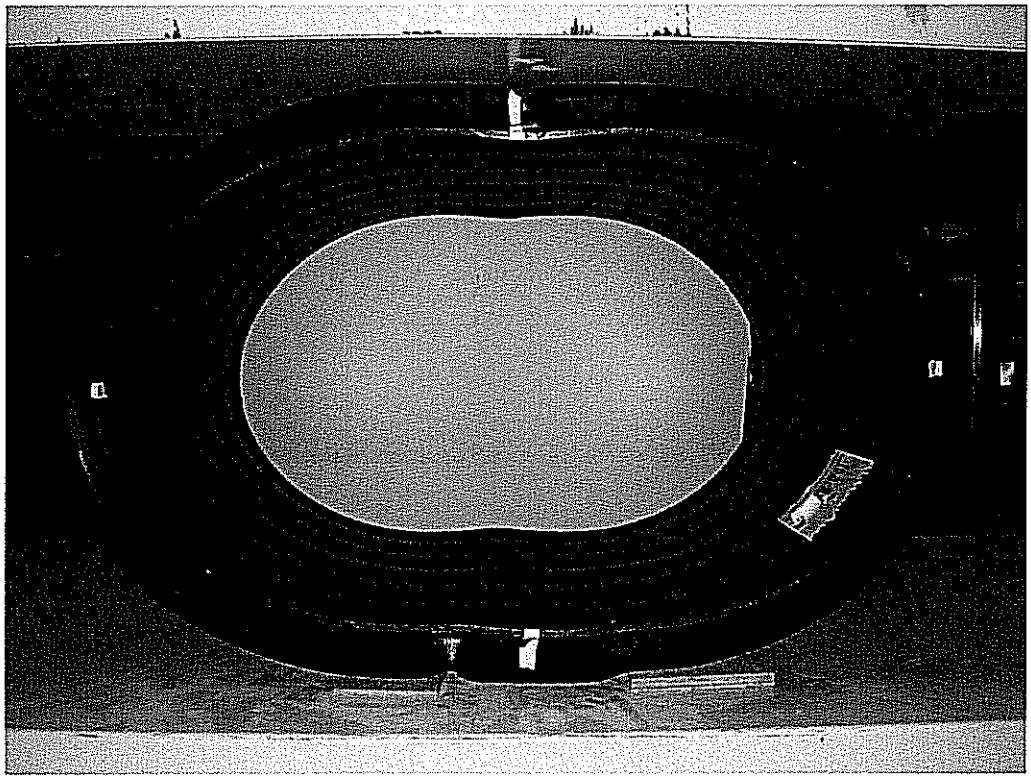


Figure 5: Test Pipe #2 Loaded to 30% Vertical Deflection

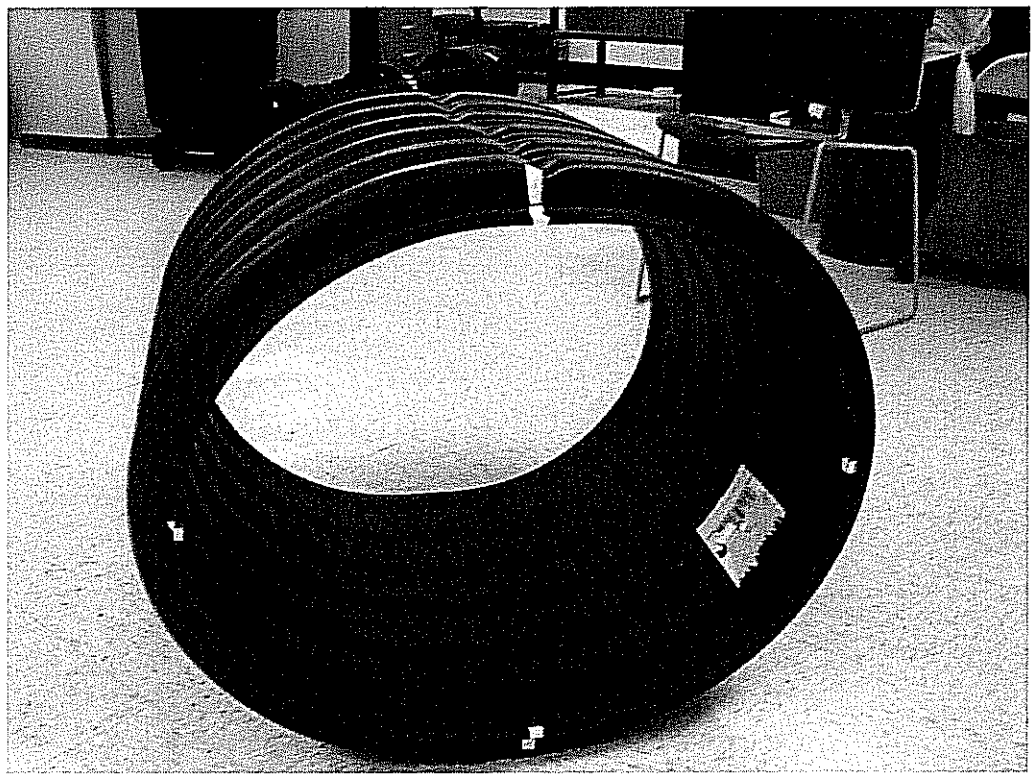


Figure 6: Test Pipe #2 Immediately After Load Test

Parallel-Plate Load (ASTM D-2412) Test – Data Sheet

Description of Test Pipe	24" Dia. Corrugated HDPE (Test Specimen 3)		
Manufacturer	Blue Diamond Industries		
Time/Date of Testing	3:30 p.m. on June 7, 2006		
Room Temperature	22 °C		
Test Performed by	Dr. T. Masada		
Length of Test Specimen (inches)	(L1) 23.6065	(L2) 23.3535	(L3) 23.2945
	(L4) 23.5295	Ave. L = 23.4460	
Wall Thickness of Test Specimen (inches)	(T1) 2.0965	(T2) 2.0680	(T3) 2.1050
	(T4) 2.1190	(T5) 2.1170	(T6) 2.0590
	(T7) 2.0520	(T8) 2.0630	Ave. T = 2.0849
Outside Diameter of Test Specimen (based on caliper measurements)	Max. OD = NA	Min. OD = NA	
	Ave. OD = NA		
	[Note] This product is ID-controlled. OD = ID + 2T = 23.9404 + 2(2.0849) = 28.1102 inches.		
Inside Diameter of Test Pipe (based on caliper measurements) (inches)	(ID1) 23.9335	(ID2) 23.9870	(ID3) 23.9585
	(ID4) 23.8825	Ave. ID = 23.9404	
Test Results (see also Figure 12 on Page 12)	Pipe stiffness (PS) values are: 33.44 lb/in/in @ 5% deflection 27.68 lb/in/in @ 10% deflection 22.94 lb/in/in @ 15% deflection 18.93 lb/in/in @ 20% deflection 13.20 lb/in/in @ 30% deflection [Note] Loading rate set at 0.5 in/minute.		
Additional Information (see Figures 7 through 9 in this report)	File No. = #53-8 Crimping of the wall section and slight reversed curvature began appearing at the invert from vertical deflection of about 24%. The same conditions also started developing at the crown from vertical deflection of about 28%. The load vs. deflection curve had no apparent peak.		

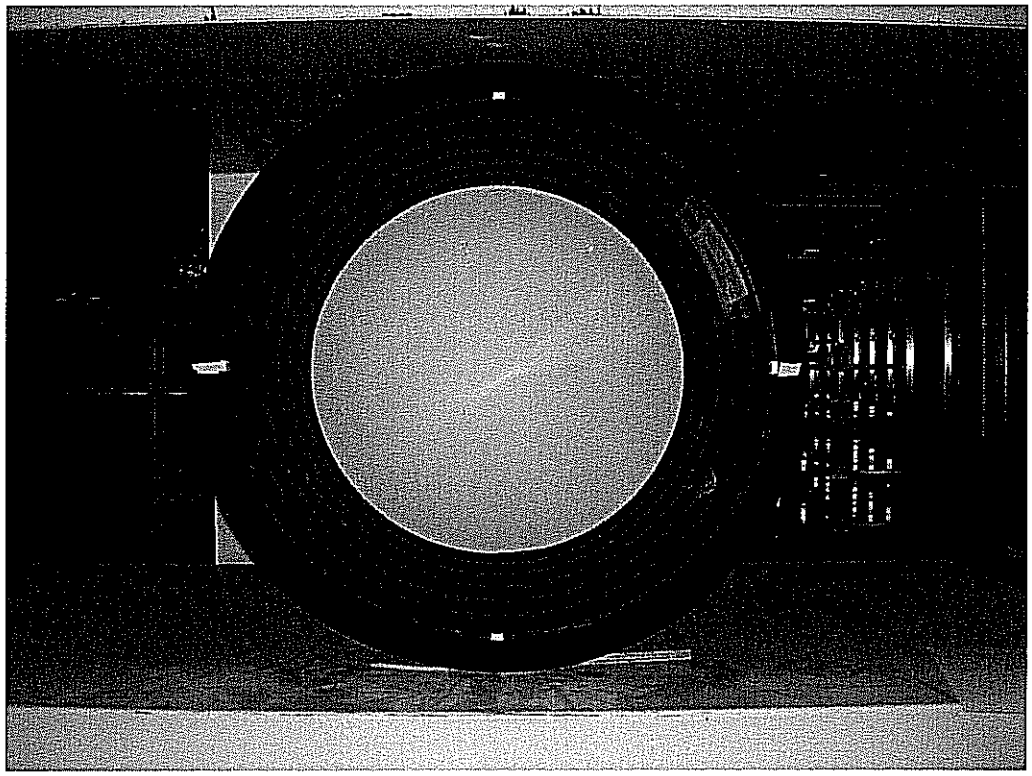


Figure 7: Test Pipe #3 at Beginning of Parallel Load Test

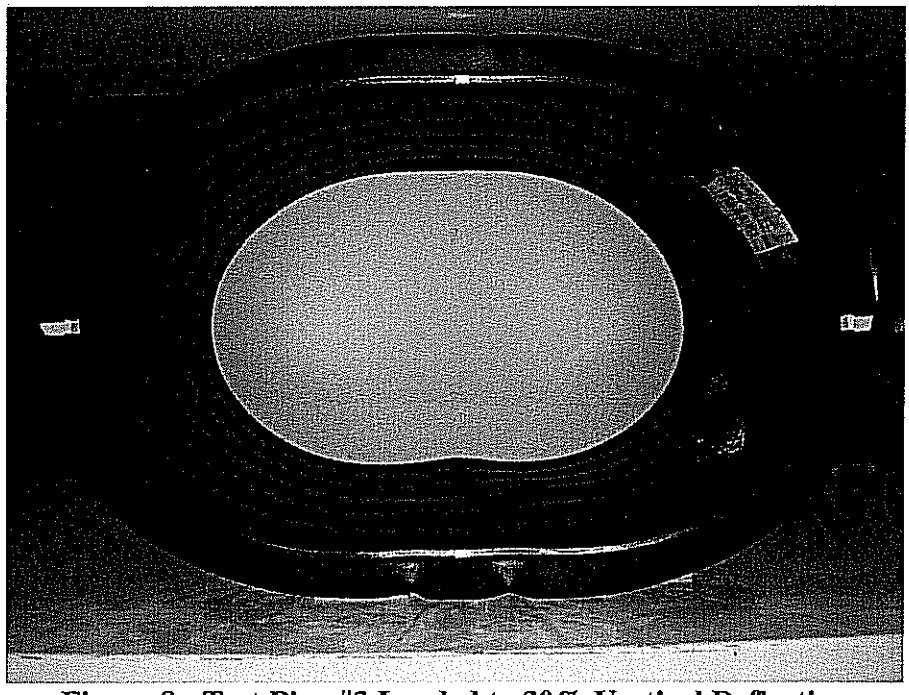


Figure 8: Test Pipe #3 Loaded to 30% Vertical Deflection

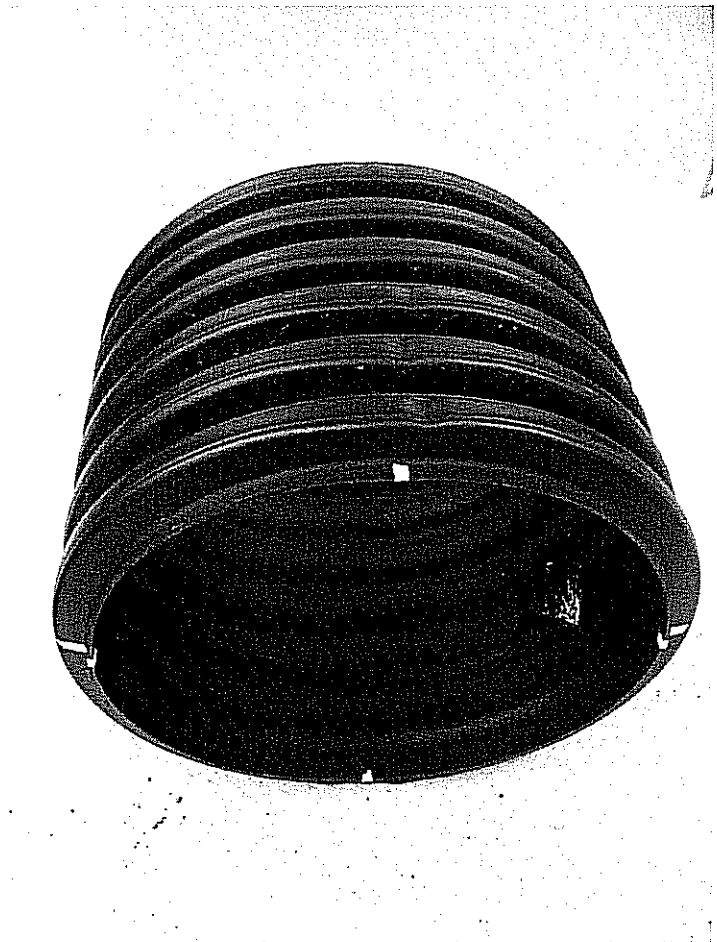


Figure 9: Test Pipe #3 Immediately After Load Test

Summary of Test Results

Seam Position:

4:30 and 10:30	for Test Pipe #1
6:00 and 12:00	for Test Pipe #2
3:00 and 9:00	for Test Pipe #3

Pipe Stiffness Values @ 5% Vertical Deflection:

Minimum PS =	33.44 lb/in/in (= 230.6 kPa)
Maximum PS =	34.85 lb/in/in (= 240.3 kPa)
Average PS =	34.09 lb/in/in (= 235.1 kPa)

Vertical Deflection @ Peak Load:

= 20%	for Test 1
= 22%	for Test 2
= 30+%	for Test 3

Vertical Deflection @ First Sign of Wall Buckling:

= 20%	for Test 1
= 22%	for Test 2
= 24%	for Test 3

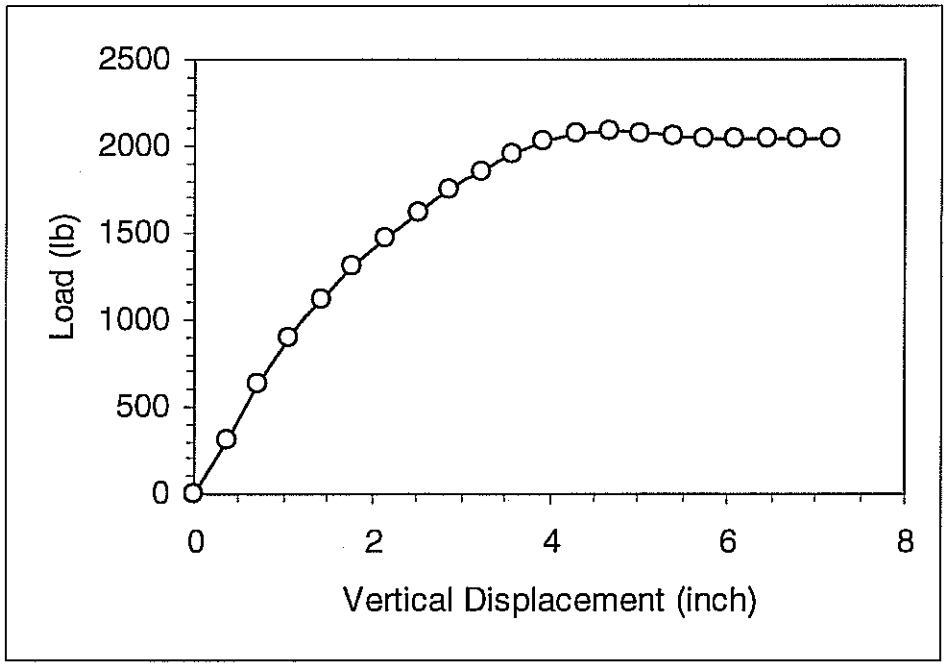


Figure 10: Load vs. Displacement Plot for Test Pipe #1

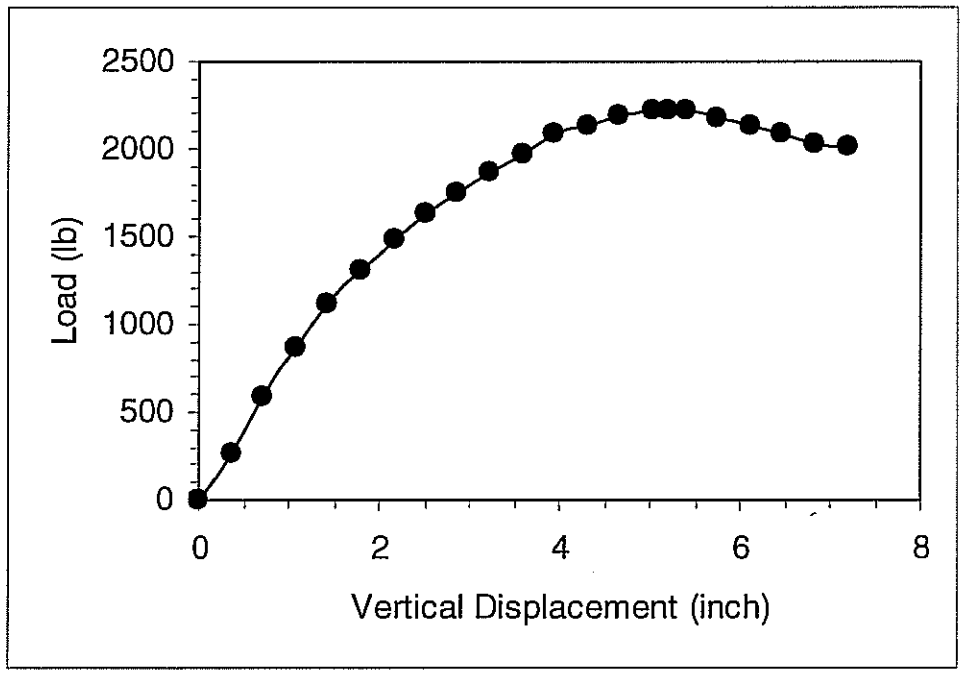


Figure 11: Load vs. Displacement Plot for Test Pipe #2

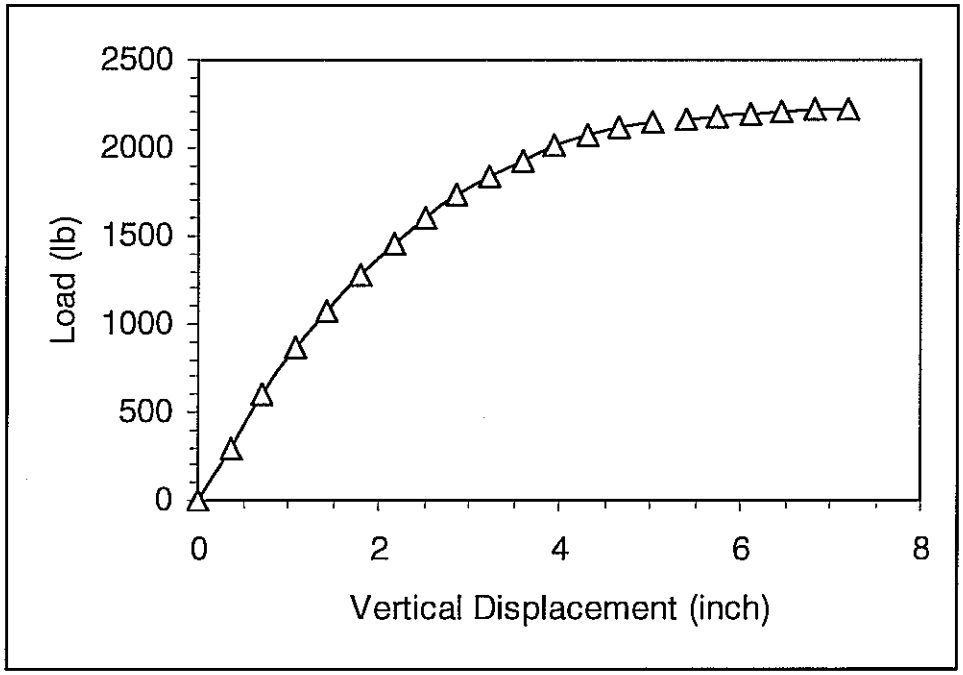


Figure 12: Load vs. Displacement Plot for Test Pipe #3

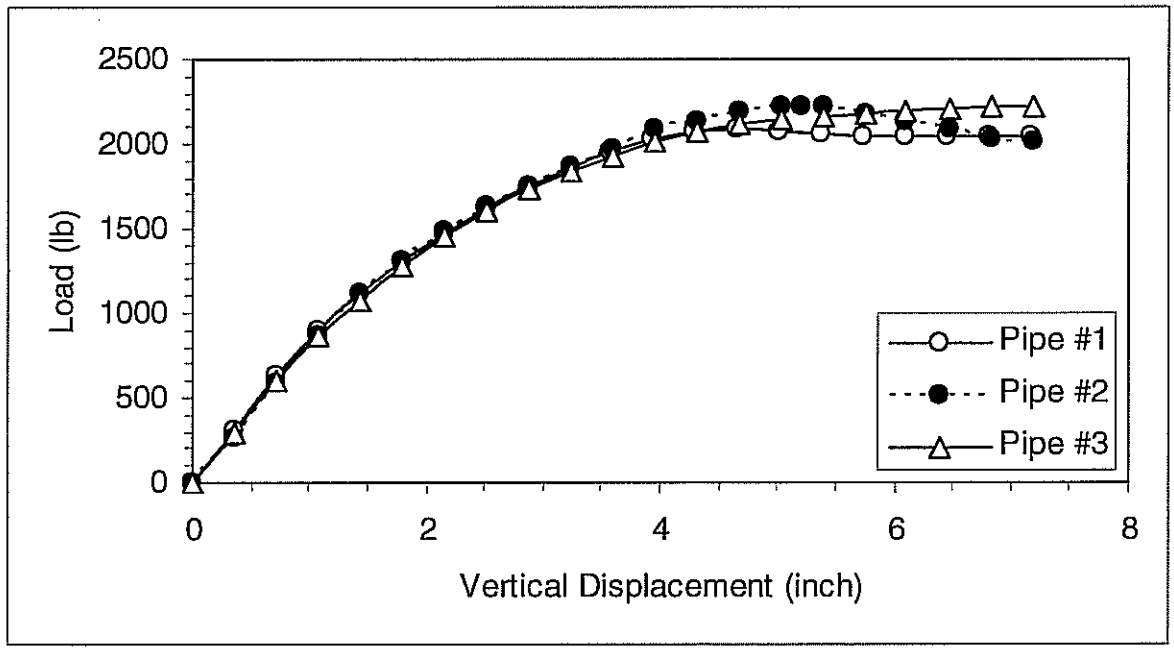


Figure 13: Load Responses of All Three Test Pipes